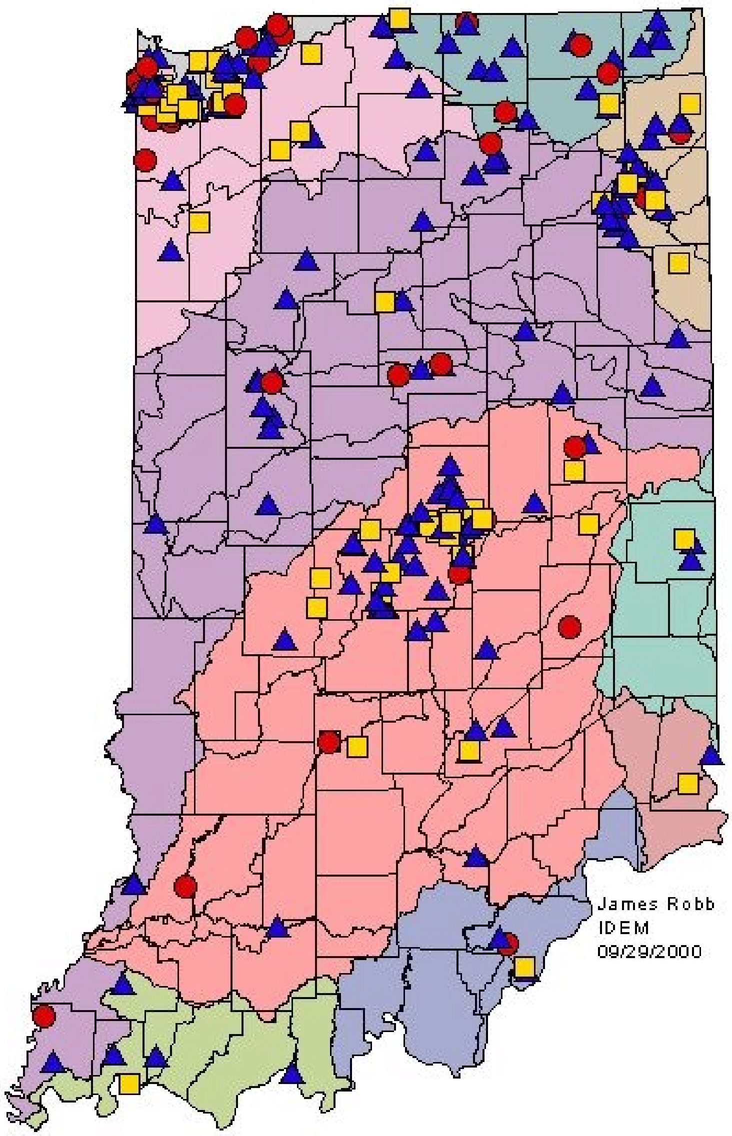
Indiana Wetland Compensatory Mitigation: Area Analysis



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Cover Art

Mitigation sites documented in 1998 and 1999 (Robb 2000). Blue triangles mark the location of constructed mitigation sites, yellow squares mark incomplete mitigation sites, and red octagons indicate the location where a mitigation site was required to be, but had not yet been attempted.

Acknowledgements

I would like to first acknowledge the USEPA Region 5 for funding this study and Cathy Garra for her technical assistance throughout this Grant. The staff at the Indiana Dept. of Environmental Management deserve special appreciation for their courage; it is not an easy thing to have a stranger dig through, analyze and criticize decisions you made five or ten years ago. The leadership at IDEM also deserves a great deal of credit for fostering an environment of honesty and integrity, which made this critique of the program possible. Finally I would like to thank Dr. Daniel Willard, my professor and mentor. Without his guidance this report would not be possible.

Executive Summary

The purpose of this study was to gauge the performance of compensatory mitigation efforts in Indiana by measuring the area of wetland established as a result of these efforts. This study used Global Positioning System (GPS) techniques to map the total area of wetland, and the area of each wetland vegetation community, established at 31 randomly selected wetland compensatory mitigation sites in Indiana. The Indiana Department of Environmental Management (IDEM) required 34.31 ha (84.7 ac) in compensation for the 13.72 ha (33.9 ac) of state waters lost through the permit actions associated with these sites. The mapping effort demonstrated that a total of 15.21 ha (37.6 ac) of wetland and other waters had established at these sites, a net gain of 1.49 ha (3.7 ac). Mapping of each vegetation community at these sites revealed that forested areas, which had a failure rate of 71%, and wet meadow areas (87% failure) were harder to establish than shallow emergent areas (17% failure) and open water areas (4% failure). Compensation for this risk of failure would require minimum mitigation ratios of 3.4:1 for forested, 7.6:1 for wet meadow, 1.2:1 for shallow emergent, and 1:1 for open water. Additional mitigation may be needed to offset the effects of temporal loss of wetland function. Although there was a net gain in area over all, forested wetlands experienced a net loss of 4.15 ha (10.3 ac) raising concerns that forested areas are being replaced with shallow emergent and open water community types.

Introduction

The Indiana Department of Environmental Management (IDEM) for many years has required the replacement of wetlands whose destruction is unavoidable. Mitigation of wetland loss consists of first taking all practicable steps to avoid and minimize the impact. Restoring or creating a wetland mitigation area then compensates for unavoidable loss. Although rare, IDEM has also required compensation in the form of enhancement of one or more of an existing wetland's functions, preservation of an existing wetland, and donations to an organization that restores wetlands. These less conventional forms of compensation were not evaluated by this study. In 1998 and 1999 IDEM inventoried 345 conventional mitigation sites required from 1986 through 1996 (Robb 2000). Applicants had constructed 214 (62%) of the sites, leaving 70 (20%) incomplete. No attempt had been made at 49 (20%) of the sites.

Numerous authors have expressed concern regarding compensatory mitigation. Early studies indicated that not only did regulatory agencies not require enough mitigation to compensate for losses (Kentula et al 1992; Sifneos, Kentula and Price 1992; Kunz, Rylko and Somers 1988), but that the mitigation was often either not done or done poorly (Redmond 1992; Erwin 1991; Reimold and Cobler 1986; Race 1985; Eliot 1985; Race and Christie 1982). A recent study in Ohio showed that some agencies may still not require enough in compensatory mitigation (Sibbing 1997). Other recent studies found that a large portion of the required compensatory mitigation is still not being constructed (Robb 2000; Mockler et al 1998; Race and Fonseca 1996; Johnson et al 2000). The compensatory mitigation that is being constructed often does not compensate for what was lost (Gwin, Kentula and Shaffer 1999; Magee et al 1999; Gallihugh 1998; Mockler et al 1998; Fennessy and Roehrs 1997). On the positive side Wilson and Mitsch (1996) found four of the five sites they looked at to be both in compliance and at least moderately successful. Fennessy and Roehrs (1997) found that all the sites in their study had been constructed. Unfortunately none of these studies address one very important element: the size of the wetland actually established at the mitigation site. This study was designed to address this data gap. Without this information we cannot evaluate the performance of a regulatory program, since area of wetland to be established has been a constant requirement of both the US Army Corps of Engineers (USCOE) and IDEM mitigation programs. We know that mitigation is risky. The previously cited studies prove that. This risk of failure, combined with temporal loss of function, is the rational for the requiring compensatory mitigation area in excess of the area of impact. This is known as the mitigation ratio. What is an appropriate mitigation ratio? How much does a regulatory agency need to require to insure that the area lost will be replaced by the applicant's attempts?

Methods

Site Selection

In a previous inventory IDEM recorded the location of all 345 mitigation sites, and documented the construction status of each as either constructed, incomplete or no attempt (Robb 2000). The author selected the certifications at random by assigning each of the certifications with at least one site classified as constructed a computer generated random number. The certifications were then sorted in ascending order. The author measured the constructed sites required by the first sixteen certifications. A total of 31 sites were selected in this way.

Equipment

Each vegetation cover type within the wetland area of each site was mapped using a Trimble ProXR Global Positioning System (GPS) receiver. The manufacturer of this GPS unit reports its accuracy at 0.75-meters RMS after differential correction plus one part per million times the distance between the rover and the base. In no case was the distance between the base and the rover greater than 300 km. In most cases this distance was less than 100 km. All GPS data collected during this study were differentially corrected.

Photographs were taken with an Olympus D-320L at the same location as the inventory picture (Robb 2000). Additional photographs were taken at other locations as needed.

Wetland Delineation

The wetland line was drawn at the furthest extent that supported a prevalence of hydrophytic vegetation and wetland hydrology as defined by the 1987 U.S. Army Corps of Engineer 1987 Delineation Manual (Environmental Laboratory 1987). Normally the 1987 Delineation requires a site to meet three parameters: prevalence of hydrophytic vegetation, presence of one primary or two secondary indicators of wetland hydrology, and hydric soils. An exception is made in the case of man-induced wetlands. Man-induced wetlands must meet only the hydrophytic vegetation and hydrology parameters. According to the 1987 manual wetland soils are presumed to exist or to be forming if wetland hydrology exists on the man-induced wetland site. Soil information is not necessary in making a wetland determination on mitigation sites, which are by their very nature man-induced. Soils are particularly misleading on mitigation sites. In many cases mitigation has been constructed on previously drained hydric soils. Finding hydric soil indicators in these cases does not necessarily reflect current conditions. In other cases mitigation is constructed by over-digging an area and spreading a layer of wetland soil from another site. Again the existence of hydric soil indicators does not necessarily reflect current conditions at the mitigation site. Another method of mitigation is to simply excavate down to the water table. Again this may lead to the presence of hydric soil indicators, especially gley or mottling, which existed in the subsoil before it was exposed but may not be indicative of current conditions. Nevertheless, one pit was dug in each mitigation site to a depth of at least 46-cm (18 inches) except in sites that were entirely inundated.

Vegetation Cover Types

All community types where determined qualitatively by visual estimation using the following guidelines. Though some effort has been made to classify these communities, in reality each type grades into the other. There is rarely a distinct border, for example, between a meadow area and an emergent area. In the case of the forested and shrub types, the distinction made here is merely a prediction. Of course no forests have formed on any of these sites, with the exception of the mature stand of trees that was flooded at site 1994031M02, though most contained immature trees. In fact, few meadow communities were identified, possibly due to the invasion of these areas by *Populus deltoides* (cottonwood).

Forested vegetative communities were considered to be establishing if live tree species were moderately dense (i.e. visually estimated to be 20 foot on center or denser). Dense bands of *Populus deltoides* (cottonwood) seedlings occupied areas of many sites in areas that are generally inundated. Data from the National Oceanic and Atmospheric Association indicate that 1999 was the 17th driest year on record (NOAA 1999a). These seedlings are unlikely to persist under normal hydrological situations. For this reason on older sites (greater than 3 years old), very young (less than 20 cm tall) *Populus deltoides* seedlings alone did not qualify the area as forested, though a mixture of older cottonwood, or other tree species with the seedlings would qualify.

Shrub vegetative communities were considered to be establishing if shrub species were moderately dense (i.e. visually estimated to be 20 foot on center or denser), and tree species were sparse (i.e. visually estimated to be less than 20 foot on center). In cases where neither tree or shrub species meet the density requirement alone, a combination of tree and shrub species 20 foot on center or denser was considered forested.

Meadow vegetative communities did not meet the above criteria for *forested* or *shrub* types. These areas were dominated by plants tolerant of saturation but not prolonged inundation (e.g. *Carex spp., Euthamia spp., Panicum virgatum, Eupatorium perfoliatum, Mimulus ringens, Aster simplex, Geum spp., Panicum dichotomiflorum, Cyperus spp., Asclepias spp., Agrostis alba, Agrostis alba palustris, Lycopus spp., Impatiens spp., Verbena hastata*, etc.). These areas often included a large proportion of upland plants, facultative plants, and shallow emergent species.

Shallow vegetative communities lacked the criteria above for forested or shrub types. They differ from meadow by supporting vegetation tolerant of, shallow (less than 6 inches) inundation. These plants include *Typha spp., Sagittaria spp., Alisma spp., Scirpus tabernaemontanii, Juncus effusus, Leersia oryzoides, Polygonum spp., Sparganium spp., Eleocharis spp*., etc. These areas often contained a large proportion of *meadow* plants as well as deep emergent, but few upland species.

Deep vegetative communities lacked the above criteria for forested or shrub types. These areas were differentiated from floating by rooted plants that produce plant parts at or above the waterline. Plants typical of the deep community type were tolerant of permanent inundation greater than 12 inches deep. Typical plants include *Potamogeton spp., Nymphaea tuberosa, Nuphar spp., Polygonum amphibium*, etc.

Floating and submerged vegetative class included those communities dominated by species with adaptations that allow them to live completely (or nearly completely) submerged. The class also includes species that float in the water column or at the surface without attachment to the substrate. These species include *Chara spp., Lemma spp., Myriophyllum spp., Ceratophyllum demersum (*coontail*)*, etc.

Upland vegetative communities were those areas of the site which failed to meet the hydrophytic vegetation requirements or the indicators of hydrology listed in the 1987 US Army Corps of Engineers Delineation Manual (Environmental Laboratory 1987).

Open Water/Bare Ground this class was reserved for those areas that supported little or no vegetation. This included areas with sparse vegetation visually estimated at less than 10% aerial coverage of the area.

GPS Mapping

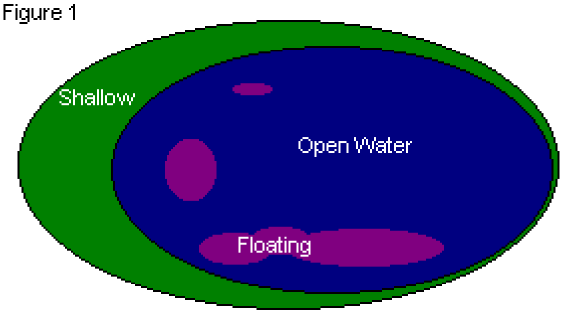
Each wetland type described above was mapped using a GPS during the summer of 1999. The author walked around the edge of each polygon recording one point every five seconds. A range finder attachment was used to map the extent of vegetation in deeper waters. The author kept notes regarding where edits needed to be made in the GIS. All GPS data were differentially corrected using the nearest base station. In no case was the base station greater than 300 km away.

GIS editing and analysis

The GPS data went through an editing process. First, if the laser range finder was used these points were assembled into polygons. Then edits were made based on the field notes. These notes corrected attributes recorded in the data logger and described how to edit the polygons. The most important aspect of the field notes was the sketch of the site that allowed the author to correctly remove overlap between the polygons. Wetland types tend to transition into each other. In many cases the types are nearly concentrically arranged. To avoid walking the same line multiple times the author recorded the outermost one first then the inner polygon with the GPS unit. If left unedited this would artificially inflate the area of the outer polygon since it also includes the area of the inner polygon. This problem was avoided by subtracting out the overlap. Upland inclusions were subtracted out in the same manner. In other cases a wetland type followed a previously recorded line for part of its length but not all of it. There was no reason to re-map this line; instead the new polygon was edited to match the previous polygon along that segment.

Imagine that Figure 1 represents a mitigation site. The white areas represent upland, the green areas represent shallow vegetative communities, the blue represents open water, and the purple are floating vegetation areas. The first step in mapping would be to identify the extent of the wetland boundary. For this example it is the outer edge of the *shallow* polygon. The observer would flag as necessary to mark the wetland boundary always looking for shifts in vegetation dominance and indicators of hydrology. The observer may also flag the line between vegetation communities where this line is convoluted or vague. The observer then walked the outer boundary of the shallow vegetation zone with the GPS unit recording the polygon. While mapping the observer would stop and make notes of vegetation, draw a sketch of the polygon being mapped, and make notes of any edits that would need to be made during processing. The observer then walked the outer edge of the open water polygon again making notes and modifying the sketch as needed. Finally the observer would walk the floating polygons, or if the water level were too deep, he would use the range finder attachment for the GPS unit to map the extent of the floating vegetation within the open water polygon. Upon return to the office the observer then used ArcView software to edit the map. First any of the floating areas which were mapped with the range finder had to be assembled into polygons from the coordinates collected. Next the open water and floating areas were subtracted from the shallow polygon creating a thin doughnut shaped polygon with a large hole in the center for the shallow area. Next the floating polygons were subtracted from the open water polygons leaving the open water polygon. In this way all overlapping areas were removed. The XTOOLS extension (DeLaune 2000) calculated the area of each of the resulting polygons automatically.

Figure 1



Results

The sixteen certifications for the 31 mitigation sites allowed impacts to 13.72 ha (33.9 ac) of wetland and other waters of the state (Figure 2). IDEM required 34.31 ha (84.7 ac) of wetland or other waters of the state in compensation, or approximately 2.5 hectares of mitigation for every one hectares of permitted impact. The GPS measurements recorded 15.21 ha (37.6 ac) of wetland and other waters that had actually established. This is a total net increase of 1.49 ha (3.7 ac). The overall area

Figure 2: Hectares Lost, Required, and Built

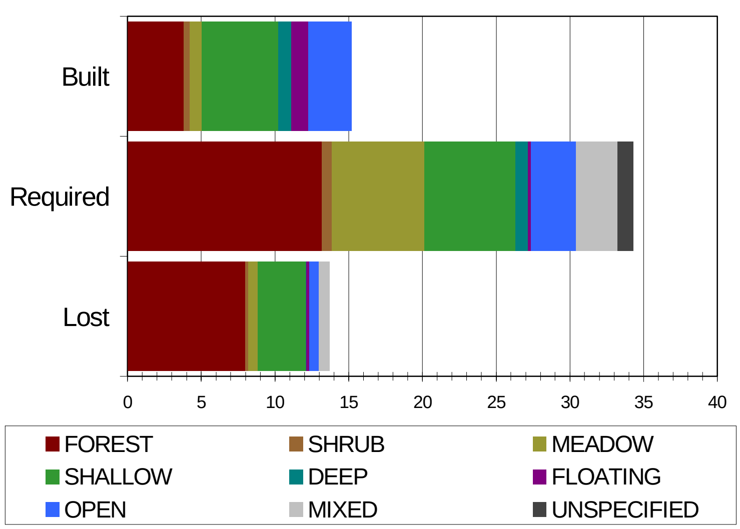
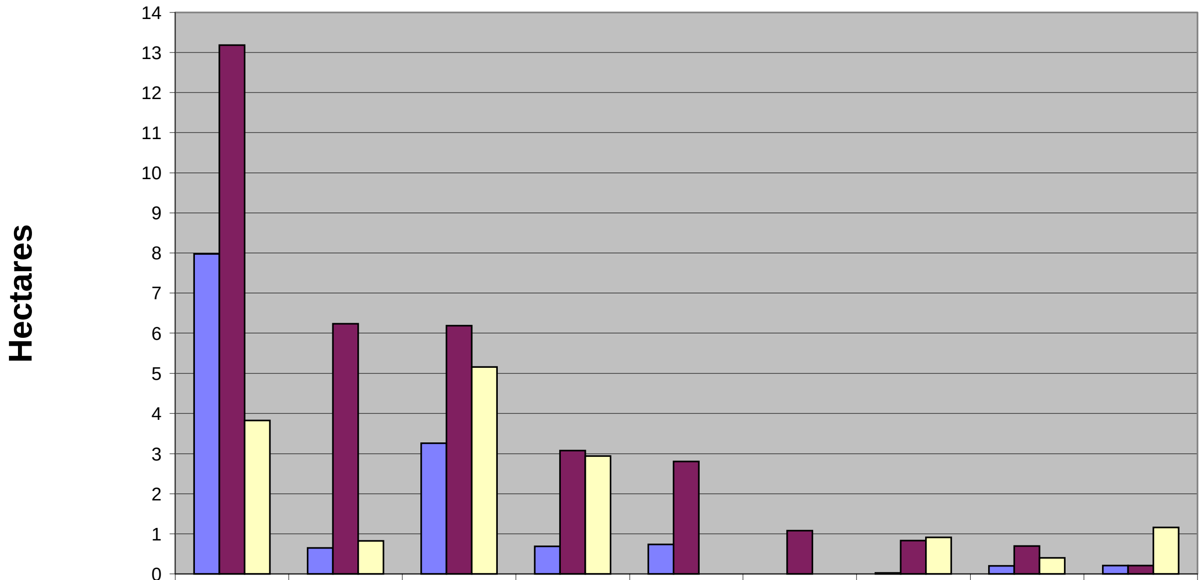


Figure 3: Area Summary



	Forest	Meadow	Shallow	Open	Mixed	Unspecified	Deep	Shrub	Floating
Lost(ha)	7.977108	0.648	3.255736	0.686	0.732	0	0.02	0.2	0.204516
Required(ha)	13.1824	6.24	6.1852	3.076	2.808	1.076	0.8352	0.6964	0.2076
Built(ha)	3.823	0.822	5.157	2.939	0	0	0.916	0.401	1.154

Vegetation Type

built was greater than the area lost in all vegetation types except for forested which saw a net-loss. IDEM permitted the loss of 7.98 ha (19.7 ac) of forested wetland, required 13.18 ha (32.56 ac) in forested mitigation, but only 3.82 ha (9.44 ac) had been established.

Discussion

No-Net-Loss?

Mitigation ratios are meant to compensate for two factors: the temporal loss of wetland function from the time the impacts are made to the time the mitigation site is mature, and the risk of mitigation failure. About 44 percent of the total wetland mitigation area required was established by the applicants' attempts. Due to mitigation ratios imposed by IDEM and the COE, this resulted in a net gain of 1.49 ha (3.7 ac) of waters of the state (including open water), and a net loss of 0.76 ha (1.9 ac) of non-open water wetland. The average ratio of 2.5:1 documented in this study does appear to compensate or nearly compensate for the risk of failure. Temporal loss of function, however, is uncompensated by this ratio.

While this area analysis seems to indicate a net-gain in wetland area, this is not entirely accurate. Nearly 35% of mitigation sites have not been constructed even though the permitted losses have occurred (Robb 2000). This study, however, does not factor in the loss of wetlands for which no mitigation was required, losses that are not regulated by IDEM, or violations that IDEM knows nothing about. Factoring in these unmitigated losses, and the temporal loss of function, Indiana's no-net-loss goal has not been achieved.

Types

Forested wetland loss approached 7.98 ha (19.7 ac), but only 3.82 ha (9.4 ac) of forested wetland were established as mitigation. Although it is IDEM's policy to require a higher mitigation ratio for forested than for herbaceous wetland types, in practice IDEM required a slightly higher ratio for the shallow impacts (1.9:1) than for forested (1.7:1), and a much higher ratio for meadow (9.6:1) and open water (4.5:1). While the forested type lost area through the certification process all other types gained area. This has the effect of trading forested wetland for the three biggest gainers: shallow emergent, open water, and, to a lesser extent, floating/submerged aquatic wetland.

The numbers in Table 1 support the theory that some wetland types are more difficult to mitigate than others. The overall failure rate can be calculated by dividing the area built by the area required. Forested wetland attempts had a 71% failure rate. Regulators would have needed to require 3.4 hectares to receive one hectare of forested wetland through mitigation. Meadow attempts had an 87% failure rate; for every hectare of meadow received IDEM would have needed to require 7.6 hectares of meadow mitigation. Shallow attempts, on the other hand, had only a 17% failure rate and open water attempts had a 4% failure rate. Not enough floating, shrub or deep types were included in the study to produce meaningful failure rates.

Table 1: Failure Rates and Ratios

Type	Failure Rate	Required : Built Area
Forest	71%	3.4:1
Shrub †	42%	1.7:1
Meadow	87%	7.6:1
Shallow	17%	1.2:1
Deep †	<0%	N/A
Floating †	<0%	N/A
Open	4%	1:1

† Too little of this type was included in the study to reach a reliable conclusion.

By dividing the area required by the area built we arrive at a ratio that indicates how many hectares regulators would have had to require to produce one hectare of the corresponding wetland type through mitigation. As noted above this overcomes the failure rate but does not compensate for temporal loss. When shallow water areas fail the reason is often too much water producing unplanned deep emergent, floating/submerged aquatic, or open water area. This explains the anomaly in Figure 3 in which more floating and deep area was built than was required.

Accuracy

Drought

The lower than normal rainfall for 1999 should be noted when evaluating the accuracy of this study. Precipitation in 1999 was the seventeenth lowest on record for the central region of the United States (NCDC 2000). Drought conditions effected portions of Indiana throughout the year. Four of the sites (1993006M01, 1996030M02, 1996030M03, and 1994042M13) were mapped during drought conditions according to the Palmer Drought Severity Index, or PDSI (NCDC 2000). Sites 1996030M02 had larger than planned open water areas. Site 1994042M13 had a large deep, floating water component. The mapping of these sites may depict more vegetation than occurs in normal years. The wetland line at site 1993006M01 and site 1996030M03 were for the most part drawn at the toe of the adjacent slope. An increase in hydrology in these areas would more likely result in a change of vegetation communities rather than an increase in size do to the confining nature of the adjacent slopes. In these cases the wetland shortage was more result of inadequate grading than inadequate rainfall. Although the remaining sites were not measured during officially recognized drought conditions (i.e. mid-range PDSI), it was a dry year. The delineation of wetlands may reflect weather variations. Determination of the degree of error associated with these variations from year to year would require repetition of these measurements.

Delineation

Wetland delineation is not a precise science. Delineation has, without a doubt, a significant potential for error. Unfortunately the author is aware of no studies which seek to statistically evaluate some measure of delineation error such as an analysis of variance. Any such study would have to employ multiple delineators who would measure the same site. This was not possible through this study as it employed just one delineator, the author, who would have likely simply replicated the same delineation in the same location committing the same errors. More study related to the accuracy of wetland delineation is needed. Delineation errors most likely outweigh any error incurred due to GPS (recording) or GIS (editing) errors, especially when the wetland line falls on flat land or a very gentle slope. The majority of these mitigation sites, however, did not occur in such a setting.

Mapping

Although information abounds on the accuracy and precision of <u>points</u> recorded via GPS, the author could find no data on the precision of <u>polygons</u> mapped with this technology. One method for estimating the polygon error associated with using GPS would be to draw a buffer around each polygon the width of the point error reported by the manufacturer, in this case 0.75 m. Half of this buffer should be inside the polygon, and half outside the polygon. This, however, would represent a worst case scenario estimate. With the exception of multi-path type error (i.e. signal bouncing off an object near the receiver such as a building), which tends to distort positions in a single direction, errors are likely to be random at positions along the polygon. If this is the case, errors along the polygon are likely to negate each other when calculating the area of the polygon. To truly estimate error one should repeatedly map an irregular polygon with the unit and determine the variance of the area calculations. It is surprising that the manufacturer does not have these data available, and equally surprising that the data are not available from the academic community.

Conclusion and Recommendations

This study measured the area of wetland and various vegetation communities established by 31 mitigation sites in Indiana, for the purpose of gauging the performance of compensatory mitigation in Indiana. The Indiana Department of Environmental Management required a total of 34.31 ha (84.7 ac) of compensatory mitigation at these 31 sites to compensate for the 13.72 ha (33.9 ac) lost. Applicants established a total of 15.21 ha (37.6 ac) of wetlands and other waters of the state at the sampled mitigation sites, resulting in a net gain of 1.49 ha (3.7 ac). Forested communities had a failure rate of approximately 71%, wet meadow had a failure rate of approximately 87%, shallow emergent had a failure rate of approximately 17%, and open water had a failure rate of approximately 4%. Based on the results of this study, mitigation ratios should be adjusted to overcome these failure rates. Regulatory agencies would have to require 3.4 ha of forested mitigation to receive 1 ha of forested wetland on the ground. Mitigation ratios would need to be 7.6:1 for wet meadow, 1.2:1 for shallow emergent, and 1:1 for open water. These ratios do not, however, account for temporal loss of wetland function, or for losses do to noncompliance. Forested community types experienced a net loss of 4.15 ha (10.3 ac), while the remaining vegetation communities experienced a net increase in area. This has the effect of trading forested wetland areas for those communities that experienced significant gains, namely shallow emergent and open water habitats.

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Appendices

Appendix A: Area Built

IDEM_ID	SITE_ID	Type	Map Date	Built(ha)	Built(ac)
1988-003-02-MTM-A					
	1988003M01				
		FOREST	9/29/1999	0.216	0.535
	1988003M02				
		FOREST	9/24/1999	0.242	0.597
	1988003M03				
		FOREST	10/1/1999	0.013	0.032
		MEADOW	10/1/1999	0.041	0.101
		SHALLOW	10/1/1999	0.195	0.482
		SHRUB	10/7/1999	0.128	0.317
	1988003M04				
		FOREST	10/7/1999	0.033	0.083
		MEADOW	10/7/1999	0.134	0.33
		OPEN	10/7/1999	0.051	0.126
		SHALLOW	10/7/1999	0.233	0.575
		SHRUB	10/7/1999	0.253	0.626
1990-002-43-MTM-A					
	1990002M01				
		FOREST	7/21/1999	0.195	0.481
		MEADOW	7/21/1999	0.009	0.023
		SHALLOW	7/21/1999	0.033	0.081
1992-003-02-ARE-A					
	1992003M01				
		DEEP	9/22/1999	0.182	0.451
		OPEN	9/22/1999	0.3	0.74
		SHALLOW	9/21/1999	0.814	2.012
1993-006-29-MTM-A					
	1993006M01				
		FOREST	9/8/1999	0.121	0.3
		SHALLOW	9/8/1999	0.013	0.033
1993-017-03-MTM-A					
	1993017M01				
		FLOATING	7/13/1999	0.065	0.162
		FOREST	7/13/1999	0.043	0.106

IDEM_ID	SITE_ID	Type	Map Date	Built(ha)	Built(ac)
		SHALLOW	7/13/1999	0.098	0.241
		SHRUB	7/13/1999	0.02	0.048
1994-005-34-HAK-A					
	1994005M01				
		FOREST	7/21/1999	0.023	0.057
		OPEN	7/21/1999	0.889	2.197
		SHALLOW	7/21/1999	0.292	0.721
1994-016-20-HAK-A					
	1994016M01				
		FLOATING	6/23/1999	0.08	0.197
		MEADOW	6/23/1999	0.016	0.041
1994-022-17-MTM-A					
	1994022M01				
		FOREST	6/22/1999	0.08	0.198
		OPEN	6/22/1999	0.242	0.598
		SHALLOW	6/22/1999	0.138	0.341
1994-031-17-MTM-A					
	1994031M01				
		FOREST	10/13/1999	0.662	1.636
		MEADOW	10/13/1999	0.047	0.116
		SHALLOW	10/13/1999	0.091	0.226
	1994031M02				
		FOREST	10/12/1999	0.133	0.329
		MATURE FOREST	10/12/1999	0.149	0.367
		MEADOW	10/12/1999	0.316	0.782
		SHALLOW	10/12/1999	0.049	0.121
1994-042-64-MTM-A					
	1994042M01				
		FOREST	8/4/1999	0.025	0.061
		MEADOW	8/4/1999	0.198	0.49
		OPEN	8/5/1999	0.092	0.228
		SHALLOW	8/4/1999	0.82	2.027
	1994042M03				
		EXISTING WETLAND	7/29/1999	0.033	0.082
		OPEN	7/29/1999	0.452	1.117
		SHALLOW	7/29/1999	0.022	0.055
	1994042M04				

IDEM_ID	*SITE_ID*	*Type*	*Map Date*	*Built(ha)*	*Built(ac)*
		FLOATING	7/28/1999	0.063	0.157
		FOREST	7/28/1999	0.002	0.006
		SHALLOW	7/28/1999	0.009	0.023
	1994042M05				
		FOREST	9/17/1999	0.045	0.111
		SHALLOW	9/17/1999	0.268	0.663
	1994042M07				
		FLOATING	9/16/1999	0.158	0.389
	1994042M08				
		FLOATING	9/16/1999	0.009	0.022
		FOREST	9/16/1999	0.003	0.007
		OPEN	9/16/1999	0.111	0.274
		SHALLOW	9/16/1999	0.039	0.095
	1994042M09				
		EXISTING WETLAND	9/17/1999	0.003	0.007
		FOREST	9/17/1999	0.003	0.008
		OPEN	9/17/1999	0.097	0.24
		SHALLOW	9/17/1999	0.027	0.068
	1994042M13				
		FLOATING	11/3/1999	0.113	0.279
		MEADOW	9/16/1999	0.002	0.004
		SHALLOW	11/3/1999	0.024	0.059
1994-054-79-MTM-A					
	1994054M01				
		FLOATING	7/20/1999	0.024	0.06
		SHALLOW	7/20/1999	0.104	0.258
	1994054M02				
		FLOATING	7/20/1999	0.107	0.263
		FOREST	7/20/1999	0.038	0.093
	1994054M03				
		OPEN	7/20/1999	0.03	0.075
		SHALLOW	7/20/1999	0.075	0.184
1995-063-45-MTM-A					
	1995063M01				
		DEEP	7/15/1999	0.647	1.598
		EXISTING WETLAND	7/15/1999	0.42	1.037
		FOREST	7/15/1999	0.751	1.855
		MEADOW	7/15/1999	0.059	0.146

IDEM_ID	SITE_ID	Type	Map Date	Built(ha)	Built(ac)
		OPEN	7/15/1999	0.132	0.325
		SHALLOW	7/15/1999	0.918	2.267
1996-030-32-HAK-A					
	1996030M02				
		DEEP	9/2/1999	0.087	0.215
		FLOATING	9/2/1999	0.283	0.699
		FOREST	8/30/1999	0.041	0.101
		OPEN	11/3/1999	0.145	0.358
		SHALLOW	8/30/1999	0.037	0.091
	1996030M03				
		FLOATING	9/3/1999	0.033	0.082
		FOREST	9/3/1999	0.047	0.117
		OPEN	9/3/1999	0.398	0.983
1996-085-45-MTM-A					
	1996085M01				
		FOREST	8/10/1999	0.143	0.353
1996-089-79-MTM-A					
	1996089M01				
		FLOATING	7/19/1999	0.219	0.541
		FOREST	7/19/1999	0.874	2.159
		SHALLOW	7/19/1999	0.845	2.088
1996-092-71-HAK-A					
	1996092M01				
		FOREST	9/15/1999	0.09	0.222

Appendix B: Area Lost

IDEM_ID	Type	Loss(ha)	Loss(ac)
1988-003-02-MTM-A			
	FOREST	4.44	11.10
1990-002-43-MTM-A			
	MIXED	0.6	1.50
1992-003-02-ARE-A			
	FOREST	0.548	1.37
	OPEN	0.348	0.87
1993-006-29-MTM-A			
	FOREST	0.036	0.09
	MEADOW	0.32	0.80
1993-017-03-MTM-A			
	FOREST	0.156	0.39
1994-005-34-HAK-A			
	SHALLOW	0.104	0.26
1994-016-20-HAK-A			
	DEEP	0.02	0.05
1994-022-17-MTM-A			
	FOREST	0.116	0.29
	SHALLOW	0.132	0.33
1994-031-17-MTM-A			
	MEADOW	0.32	0.80
	MIXED	0.132	0.33
	OPEN	0.132	0.33
	SHALLOW	0.656	1.64
1994-042-64-MTM-A			
	FOREST	0.916	2.29
	MEADOW	0.008	0.02
	OPEN	0.206	0.52
	SHALLOW	0.302	0.76
	SHRUB	0.12	0.30
1994-054-79-MTM-A			
	FOREST	0.148	0.37

IDEM_ID	Type	Loss(ha)	Loss(ac)
1995-063-45-MTM-A			
	FOREST	0.48	1.20
	SHALLOW	1.16	2.90
	SHRUB	0.08	0.20
1996-030-32-HAK-A			
	SHALLOW	0.88	2.20
1996-085-45-MTM-A			
	FOREST	0.148	0.37
1996-089-79-MTM-A			
	FLOATING	0.204516	0.51
	FOREST	0.485108	1.21
	SHALLOW	0.021736	0.05
	SHRUB	0	0.00
1996-092-71-HAK-A			
	FOREST	0.504	1.26

Appendix C: Area Required

IDEM_ID	*SITE_ID*	*Type*	*Required(ha)*	*Required(ac)*
1988-003-02-MTM-A				
	1988003M01			
		FOREST	0.28	0.7
	1988003M02			
		FOREST	0.52	1.3
	1988003M03			
		FOREST	1.48	3.7
	1988003M04			
		DEEP	0.02	0.05
		FOREST	1.74	4.35
		SHRUB	0.4	1
1990-002-43-MTM-A				
	1990002M01			
		UNSPECIFIED	0.8	2
1992-003-02-ARE-A				
	1992003M01			
		FOREST	2.56	6.4
		OPEN	1.356	3.39
		SHALLOW	0.44	1.1
		UNSPECIFIED	0.172	0.43
1993-006-29-MTM-A				
	1993006M01			
		MEADOW	0.52	1.3
1993-017-03-MTM-A				
	1993017M01			
		MIXED	0.28	0.7
1994-005-34-HAK-A				
	1994005M01			
		SHALLOW	0.544	1.36
1994-016-20-HAK-A				
	1994016M01			

IDEM_ID	SITE_ID	Type	Required(ha)	Required(ac)
		SHRUB	0.04	0.1
1994-022-17-MTM-A				
	1994022M01			
		MIXED	0.3	0.75
1994-031-17-MTM-A				
	1994031M01			
		FOREST	0.312	0.78
		MEADOW	1.248	3.12
	1994031M02			
		FOREST	0.36	0.9
		MEADOW	1.44	3.6
1994-042-64-MTM-A				
	1994042M01			
		FOREST	0.62	1.55
		MEADOW	0.984	2.46
		SHALLOW	1.2	3
		SHALLOW	0.112	0.28
		UNSPECIFIED	0.032	0.08
	1994042M02			
		DEEP	0.028	0.07
		FOREST	0.012	0.03
	1994042M03			
		DEEP	0.0892	0.223
		FOREST	0.0588	0.147
		SHALLOW	0.098	0.245
		SHRUB	0.0124	0.031
	1994042M04			
		DEEP	0.122	0.305
		FOREST	0.0332	0.083
		SHALLOW	0.0388	0.097
	1994042M05			
		SHALLOW	0.504	1.26
	1994042M06			
		SHALLOW	0.08	0.2
	1994042M07			

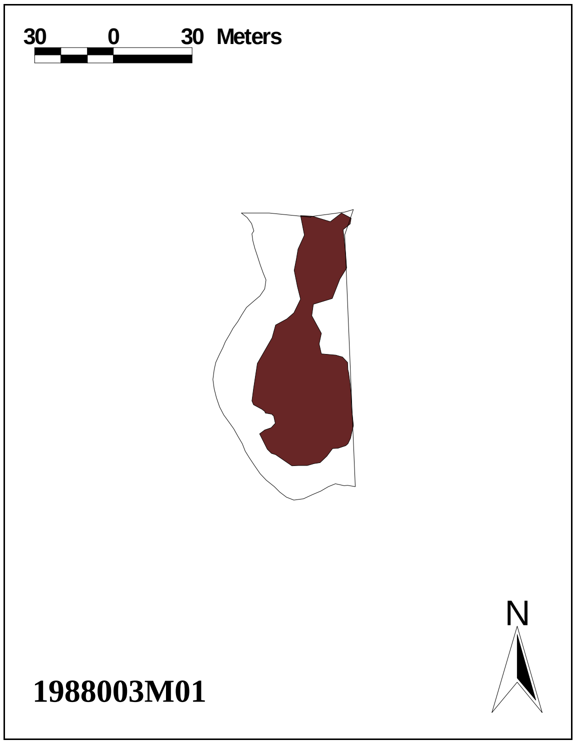
IDEM_ID	SITE_ID	Type	Required(ha)	Required(ac)
		DEEP	0.156	0.39
		SHALLOW	0.008	0.02
		SHRUB	0.008	0.02
	1994042M08			
		DEEP	0.028	0.07
		SHALLOW	0.04	0.1
		SHRUB	0.012	0.03
	1994042M09			
		DEEP	0.052	0.13
		SHALLOW	0.072	0.18
		SHRUB	0.012	0.03
	1994042M10			
		DEEP	0.156	0.39
		SHALLOW	0.072	0.18
		SHRUB	0.02	0.05
	1994042M11			
		SHALLOW	0.408	1.02
		SHRUB	0.152	0.38
	1994042M12			
		DEEP	0.184	0.46
		SHRUB	0.04	0.1
	1994042M13			
		SHALLOW	0.056	0.14
	1994042M14			
		SHALLOW	0.036	0.09
	1994042M15			
		UNSPECIFIED	0.072	0.18
	1994042M16			
		SHALLOW	0.072	0.18
	1994042M17			
		SHALLOW	0.048	0.12
	1994042M18			
		SHALLOW	0.128	0.32
1994-054-79-MTM-A				
	1994054M01			

IDEM_ID	SITE_ID	Type	Required(ha)	Required(ac)
		MIXED	0.4	1
	1994054M02			
		MIXED	0.468	1.17
	1994054M03			
		SHALLOW	0.452	1.13
1995-063-45-MTM-A				
	1995063M01			
		FOREST	2.36	5.9
		MEADOW	2	5
		MIXED	1.36	3.4
1996-030-32-HAK-A				
	1996030M01			
		OPEN	0.76	1.9
		SHALLOW	0.24	0.6
	1996030M02			
		SHALLOW	1.16	2.9
	1996030M03			
		OPEN	0.96	2.4
		SHALLOW	0.24	0.6
1996-085-45-MTM-A				
	1996085M01			
		FOREST	0.1	0.25
		MEADOW	0.048	0.12
1996-089-79-MTM-A				
	1996089M01			
		FLOATING	0.2076	0.519
		FOREST	2.3304	5.826
		SHALLOW	0.1364	0.341
1996-092-71-HAK-A				
	1996092M01			
		FOREST	0.224	0.56
		FOREST	0.192	0.48

Appendix D: Drought Severity

IDEM_ID	*SITE_ID*	*Map Date*	*Palmer Drought Severity Index*
1988-003-02-MTM-A			
	1988003M01	9/29/1999	mid-range
	1988003M02	9/24/1999	mid-range
	1988003M03	10/1/1999	mid-range
	1988003M03	10/7/1999	mid-range
	1988003M04	10/7/1999	mid-range
1990-002-43-MTM-A			
	1990002M01	7/21/1999	mid-range
1992-003-02-ARE-A			
	1992003M01	9/21/1999	mid-range
	1992003M01	9/22/1999	mid-range
1993-006-29-MTM-A			
	1993006M01	9/8/1999	moderate drought
1993-017-03-MTM-A			
	1993017M01	7/13/1999	mid-range
1994-005-34-HAK-A			
	1994005M01	7/21/1999	mid-range
1994-016-20-HAK-A			
	1994016M01	6/23/1999	mid-range
1994-022-17-MTM-A			
	1994022M01	6/22/1999	mid-range
1994-031-17-MTM-A			
	1994031M01	10/13/1999	mid-range
	1994031M02	10/12/1999	mid-range
1994-042-64-MTM-A			
	1994042M01	8/4/1999	mid-range
	1994042M01	8/5/1999	mid-range
	1994042M03	7/29/1999	mid-range
	1994042M04	7/28/1999	mid-range
	1994042M05	9/17/1999	mid-range
	1994042M07	9/16/1999	mid-range
	1994042M08	9/16/1999	mid-range
	1994042M09	9/17/1999	mid-range
	1994042M13	9/16/1999	mid-range
	1994042M13	11/3/1999	severe drought

IDEM_ID	SITE_ID	Map Date	Palmer Drought Severity Index
	1994042M14	7/29/1999	mid-range
1994-054-79-MTM-A			
	1994054M01	7/20/1999	mid-range
	1994054M02	7/20/1999	mid-range
	1994054M03	7/20/1999	mid-range
1995-063-45-MTM-A			
	1995063M01	7/15/1999	mid-range
1996-030-32-HAK-A			
	1996030M02	8/30/1999	mid-range
	1996030M02	9/2/1999	moderate drought
	1996030M02	11/3/1999	severe drought
	1996030M03	9/3/1999	moderate drought
1996-085-45-MTM-A			
	1996085M01	8/10/1999	mid-range
1996-089-79-MTM-A			
	1996089M01	7/19/1999	mid-range
1996-092-71-HAK-A			
	1996092M01	9/15/1999	mid-range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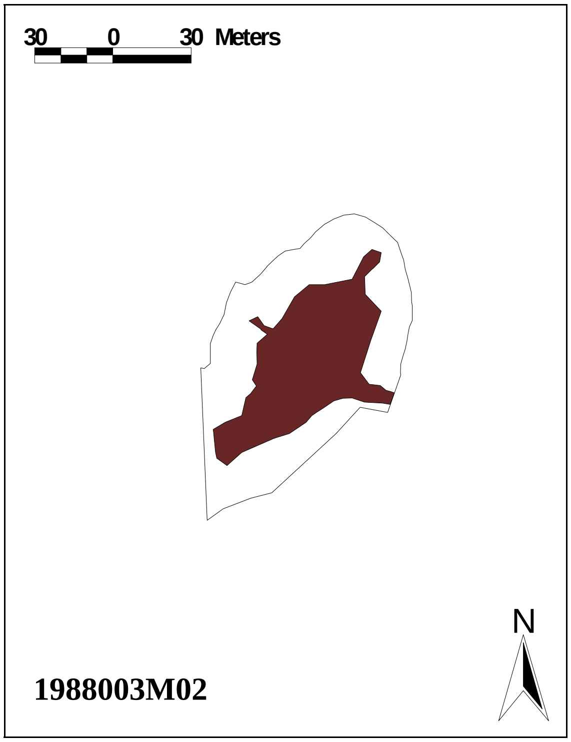
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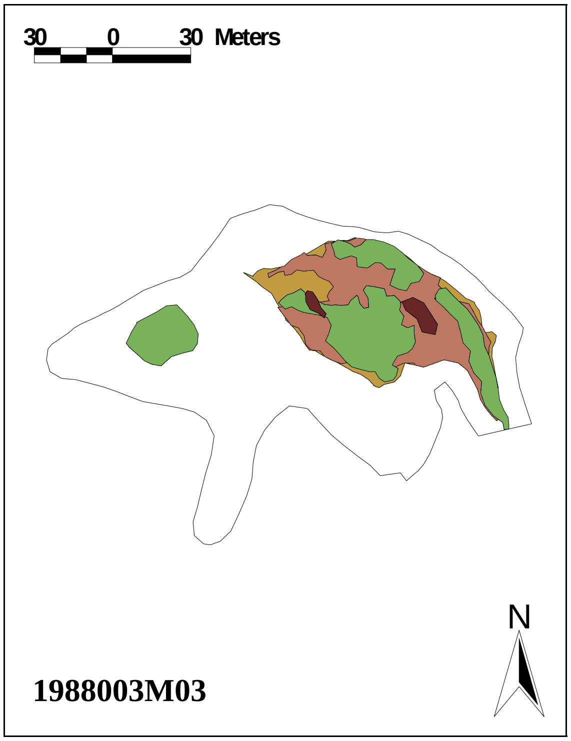
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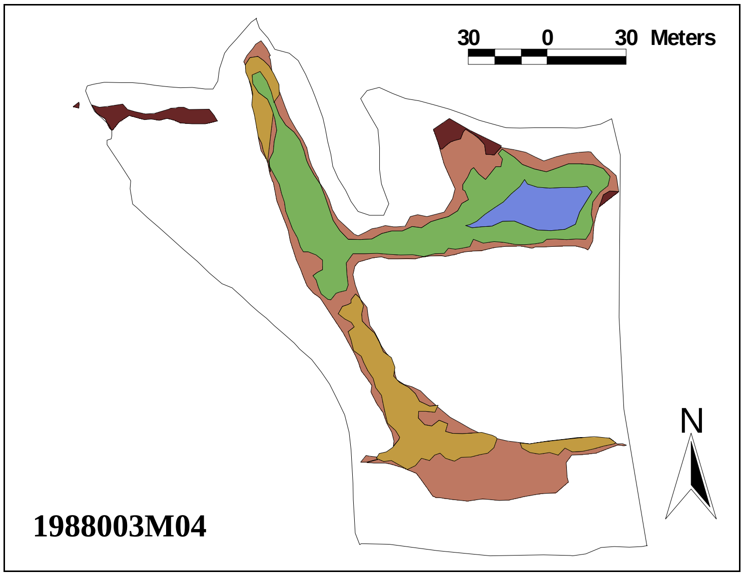
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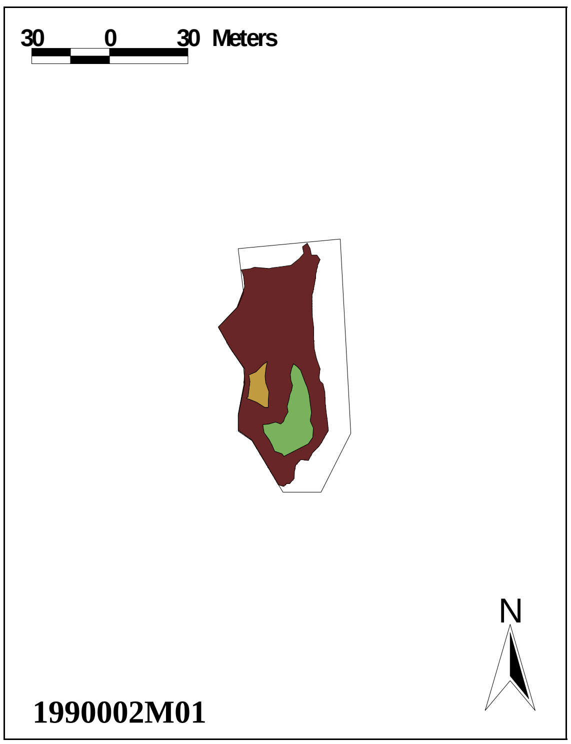
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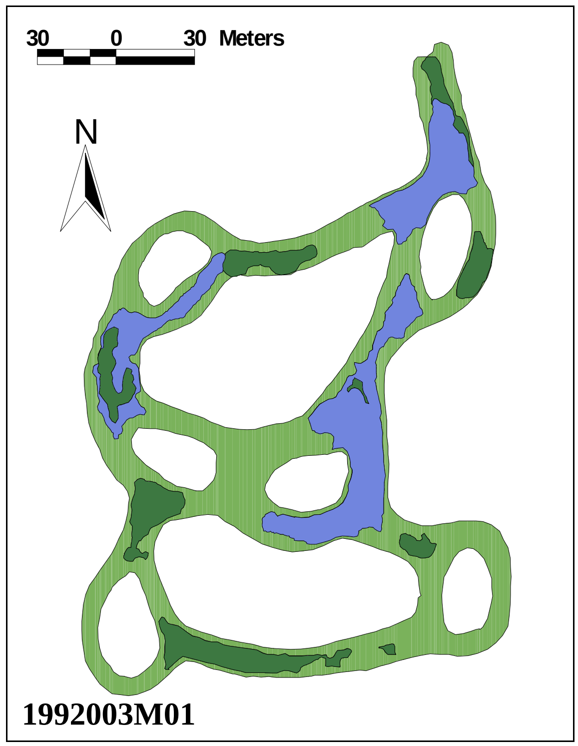
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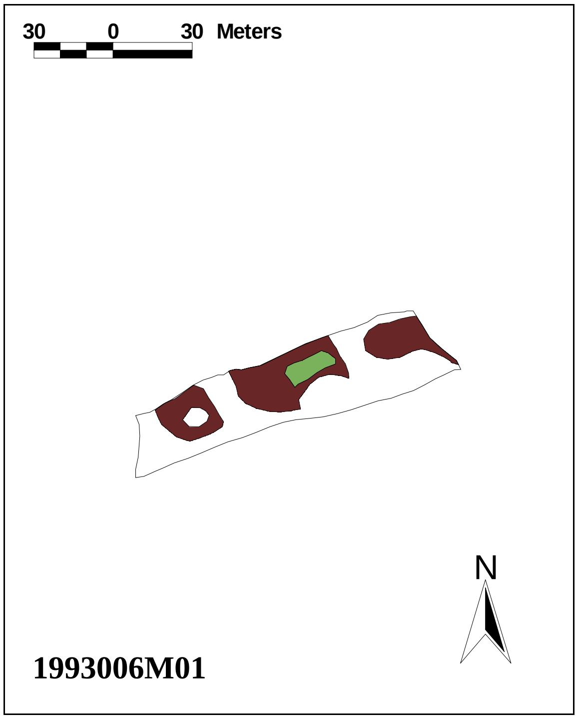
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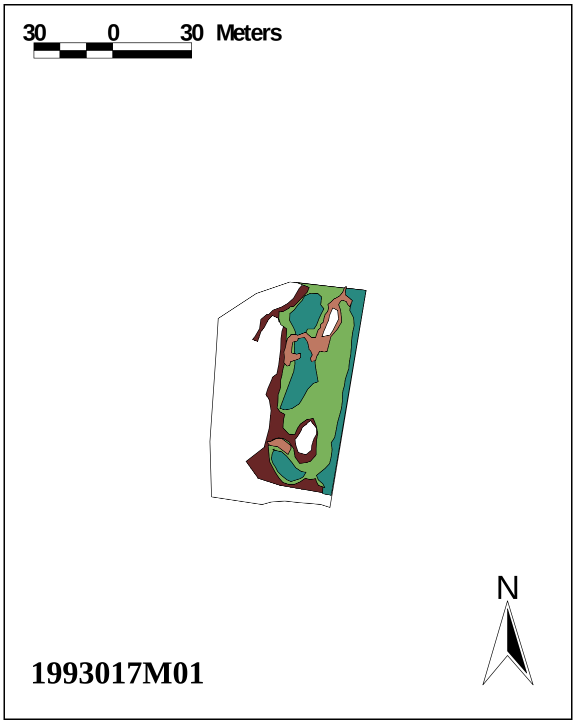
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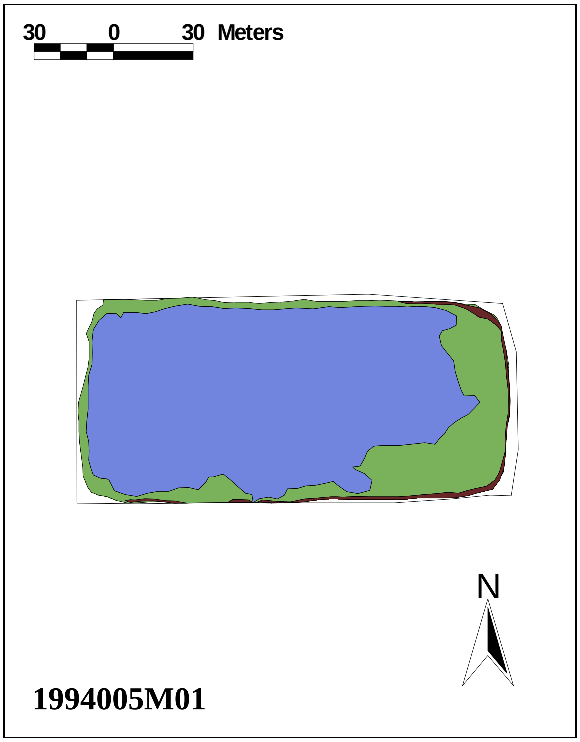
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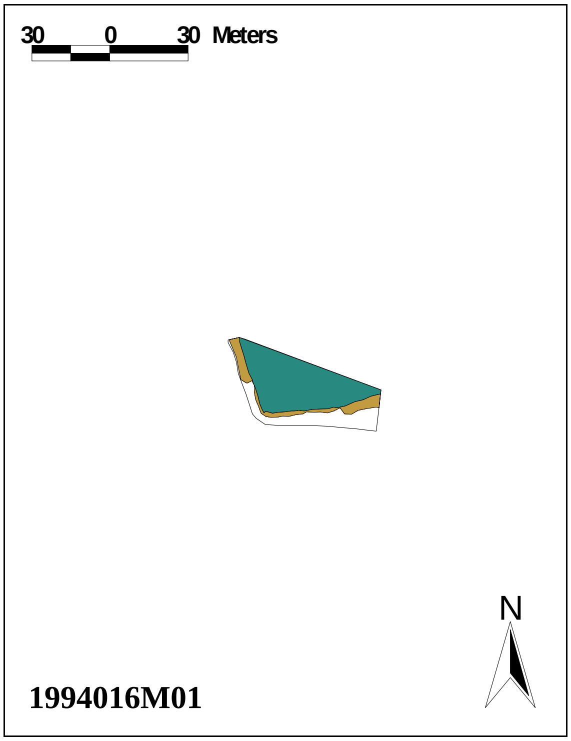
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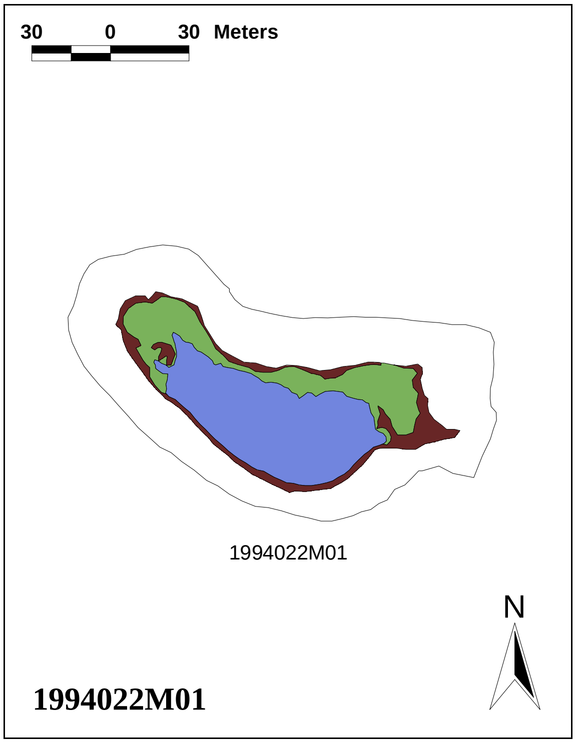
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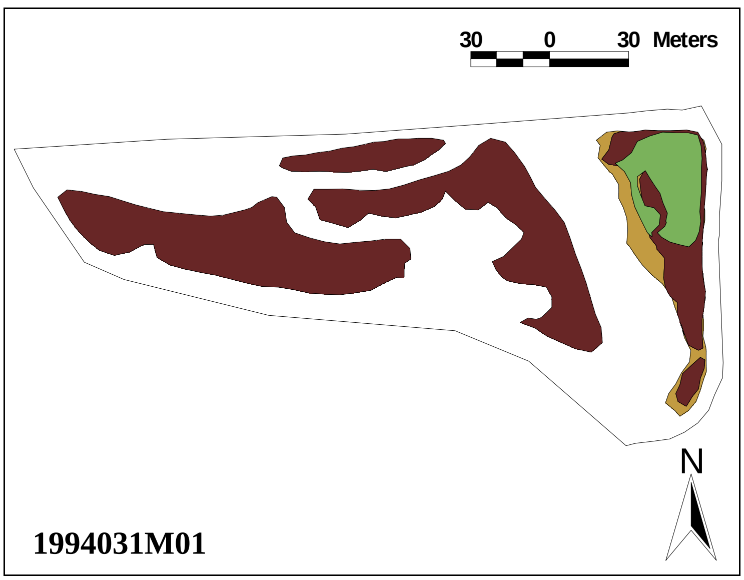
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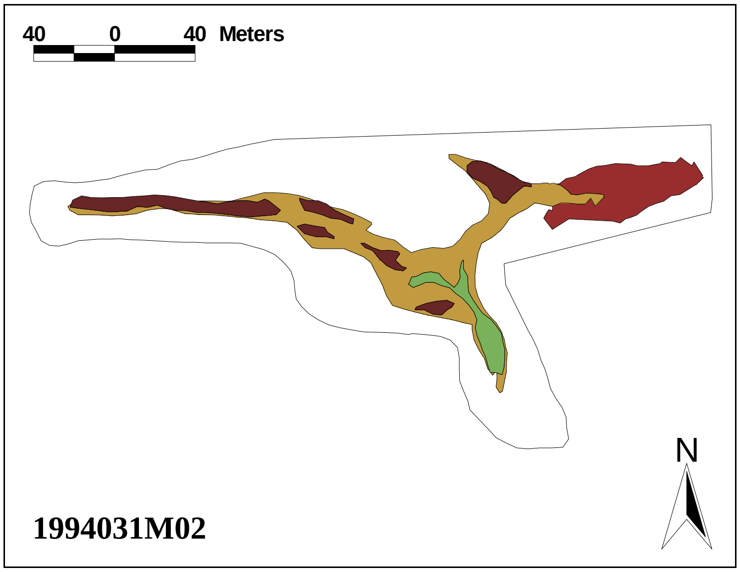
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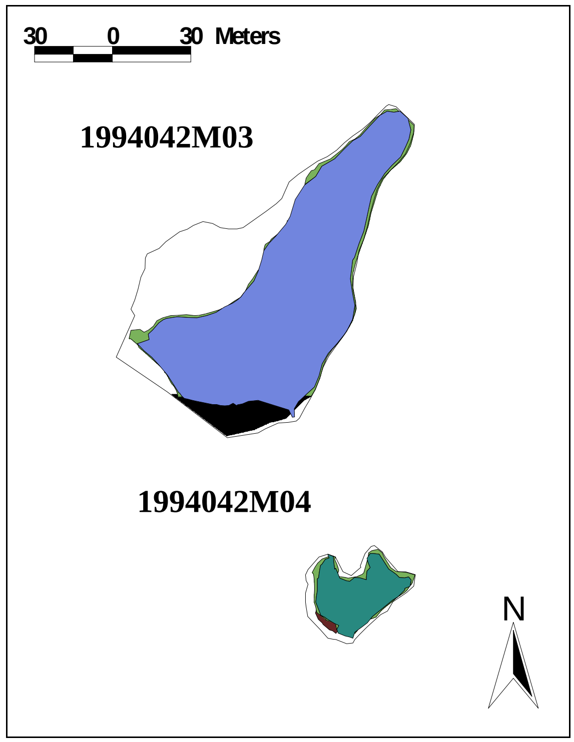
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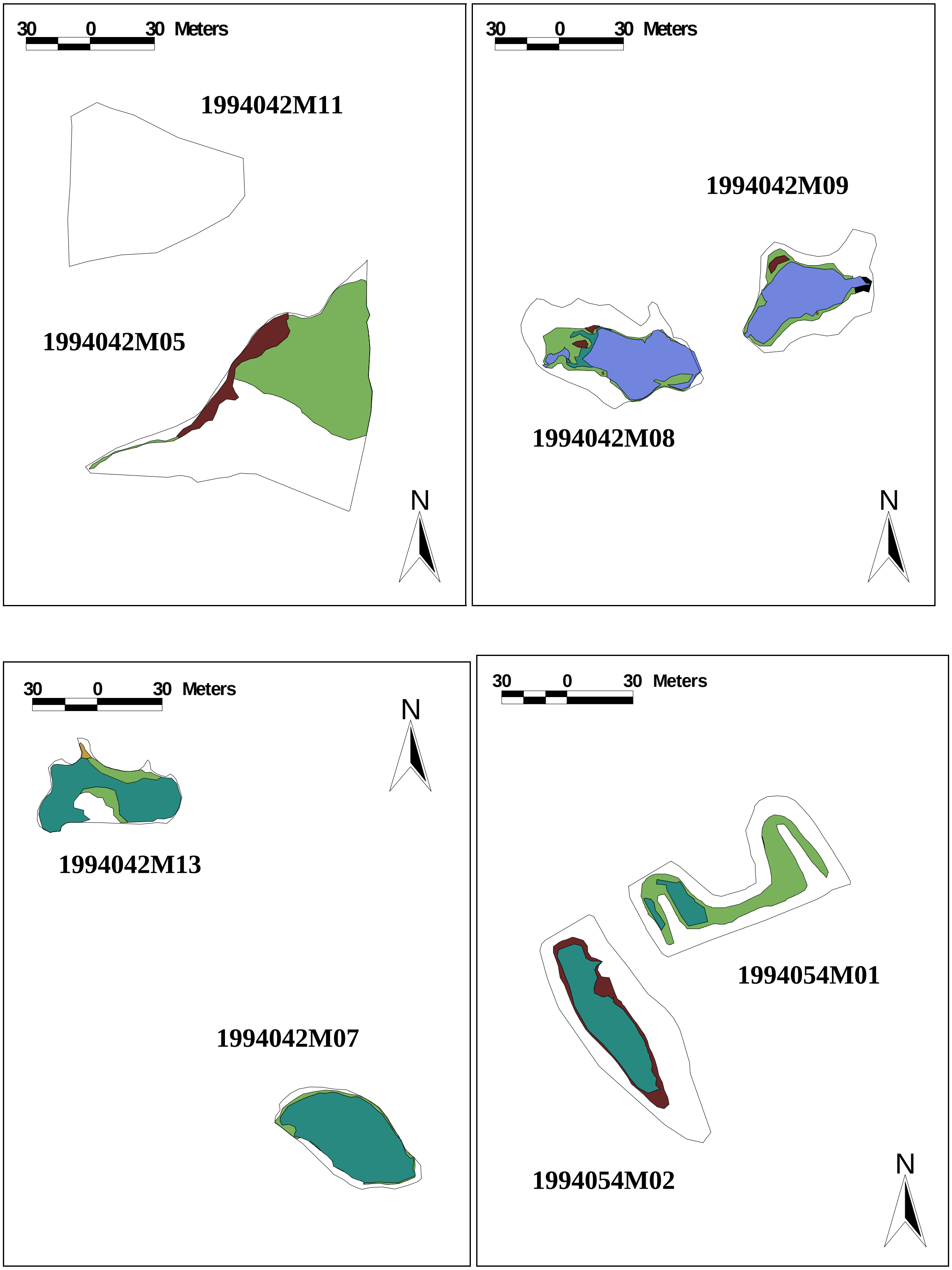
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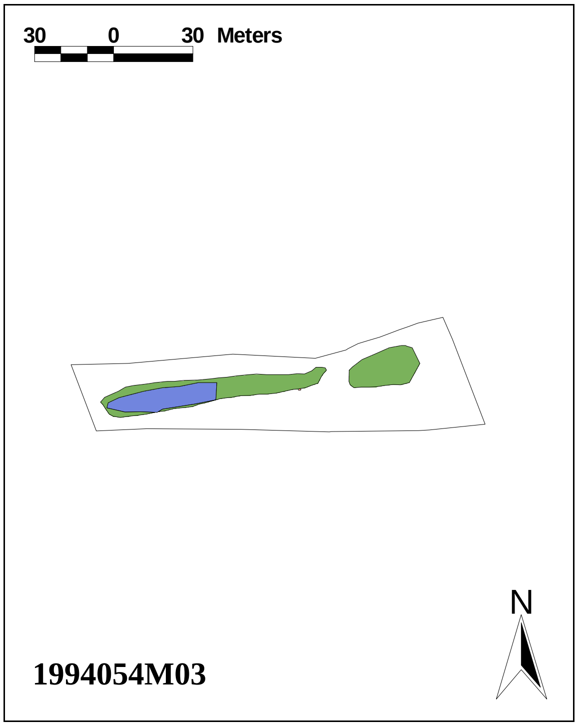
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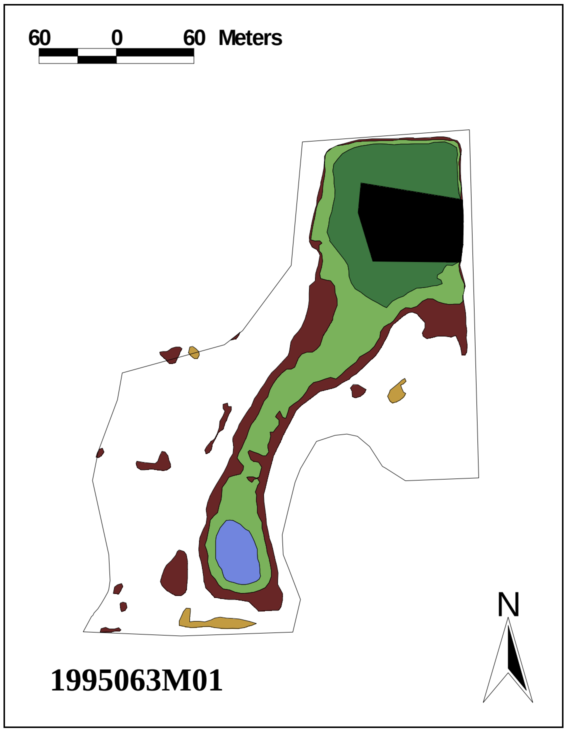
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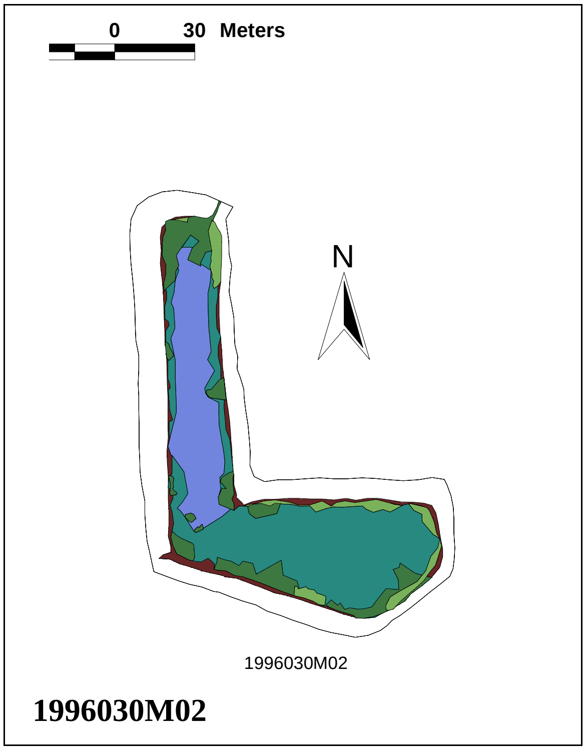
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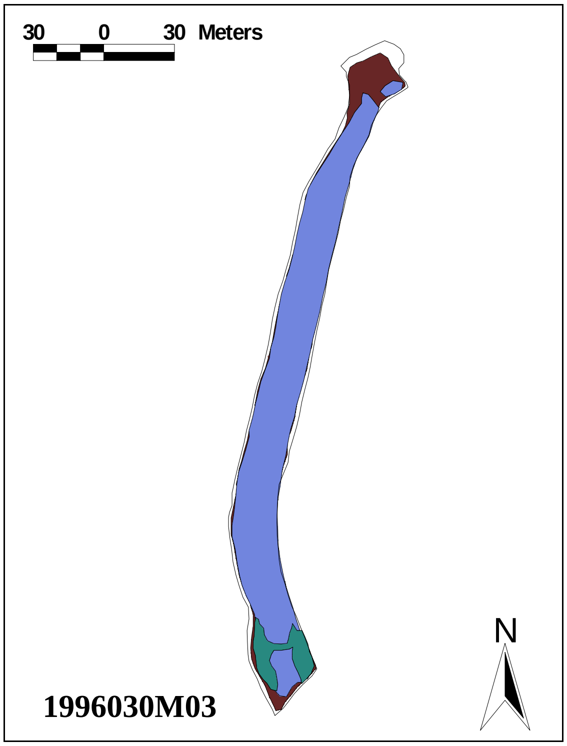
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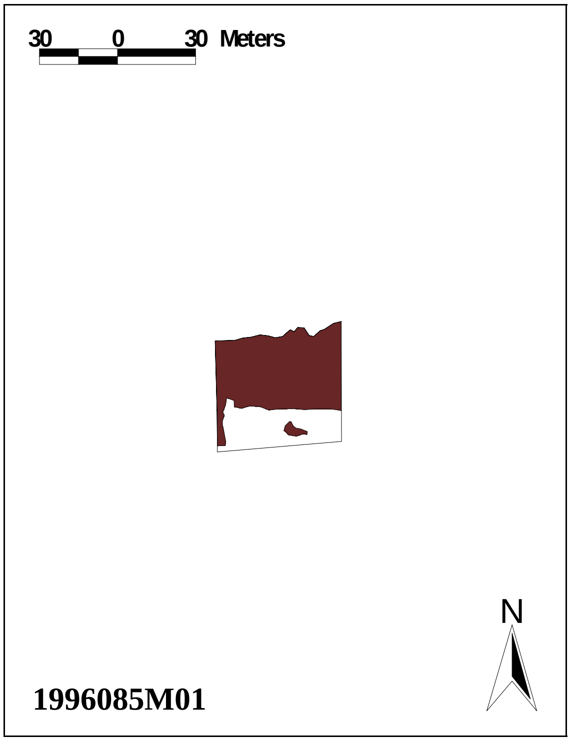
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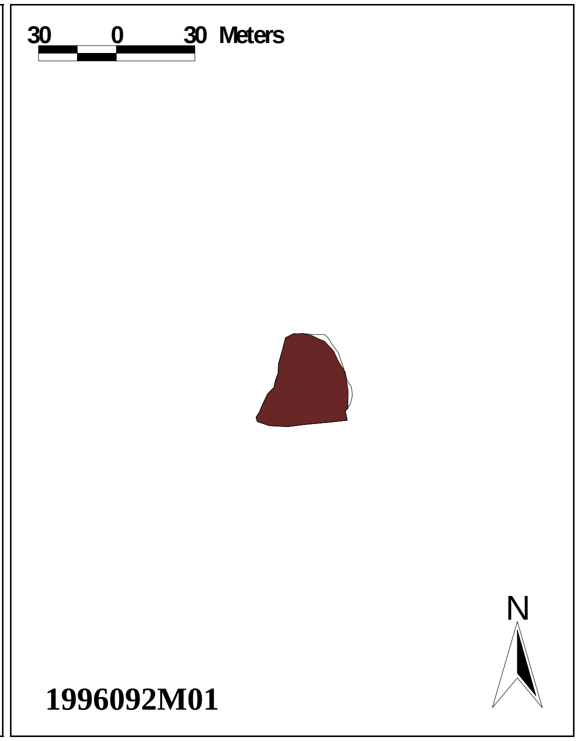
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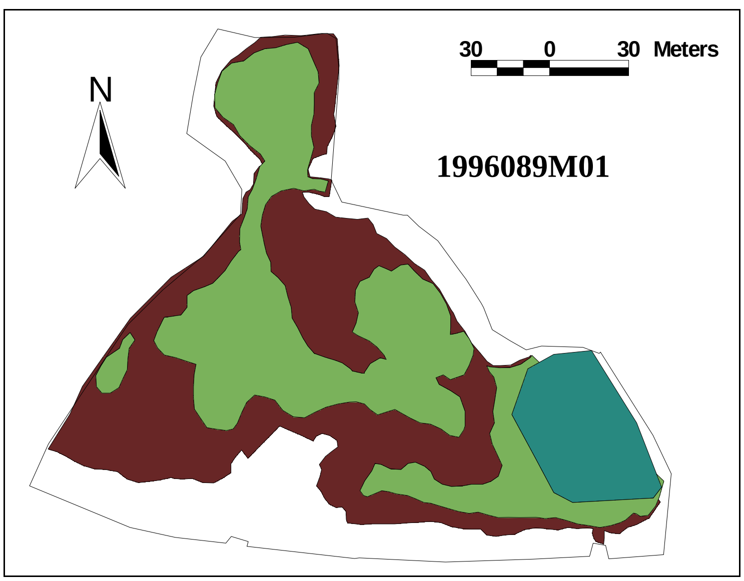
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